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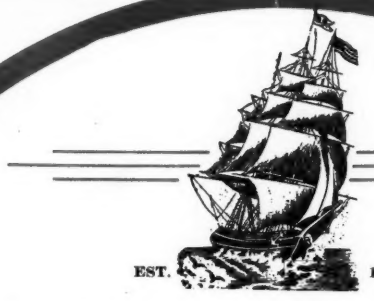
95 AUGUST 30, 1941 No. 5



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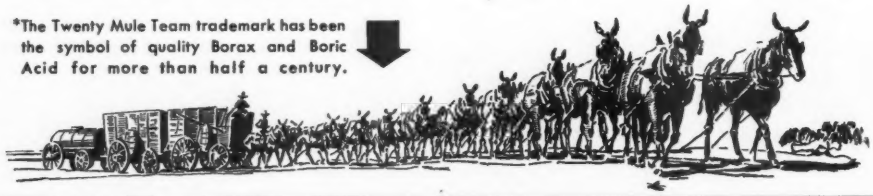

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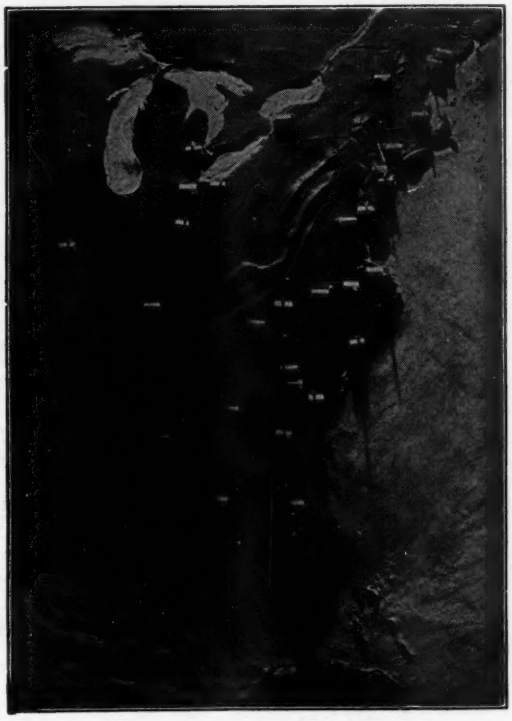

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Vol. 95 AUGUST 30, 1941 No. 5

A Critique of Field Experiments with Plant Nutrients

By DR. O. W. WILLCOX

Technical and Agricultural Editor of "Sugar," New York

Abstract

IN numerous cases, field tests with plant nutrients have been considered failures because an observed increase in yield turned out not to be statistically significant, even though the actual increases have appeared worth while.

When an analysis of variance indicates a very marked significance, the result may be accepted. But when the calculations appear to show that a visible increase is unreal, the experimenter will do well to look for supplemental information. This he may obtain by determining the positions of the experimental yields in relation to the Mitscherlich-Baule normal yield curve. In this paper, it is shown how this curve is determined without any mathematical calculations and in not more than two or three minutes; at the same time the experimenter is provided with other valuable information not obtainable by ordinary statistical methods.

Assuming that the operator is competent and conscientious and well provided with materials and assistants, a field experiment to determine the response of a soil to applications of a plant nutrient is usually carried out as follows:

The site selected for the experiment will be in an area where the soil appears to have a uniform character. The whole area will be plowed up and otherwise prepared so that all portions are left as nearly as possible in a uniform physical condition. The field is then staked out in small plots of the same area and shape. The size of these plots will be determined by the nature of the agrotype (see further on) which is to be used as the test plant. If there are to be three graded amounts of the nutrient, each in nine replications, the number of plots will be 27. The proper arrangement of the plots, or the distribution of the treatments over the area, is a matter of dispute among experimental statisticians. Some insist that the plots be randomized; others, while admitting that randomization is correct in statistical theory, point out that where the number of replications is small (which for economic reasons is here unavoidably the case), the actual difference between the results of a randomized and a systematic distribution is negligible, so the systematic arrangement is preferred by plantation agronomists on account of its practical convenience.

In any case, each plot receives its allotment of the nutrient and the plots are all planted with the same amount of seed of the same character. Especial care is taken to secure the same uniform stand or density of planting on all plots. During growth all plots are given the same cultural treatment and all are harvested at the same stage of maturity. The produce of each plot is separately weighed on scales of tested accuracy. Throughout the whole process the main duty of the operator is to make and keep the experimental field a closed system, *i.e.*, closed against the entry of extraneous or irrelevant influences.

Nevertheless, even when the operator has fulfilled the obligation to assure that no plot receives any differential treatment other than its differential amount of the nutrient, when the produce from the different plots is weighed and the figures tabulated and compared, they

generally show numerous and sometimes large discrepancies.

Consider, for example, the Hamakua field test[1] with potash on sugar cane which is summarized in Table 1. The table shows that the G plots, which received no potash, produced yields ranging from 38.3 up to 67.2 tons to the acre; the H plots, which were treated with a medium amount of potash, yielded at rates between 36.3 and 65.3 tons; the I plots, which got a doubled amount of potash, yielded between 43.5 and 63.1 tons. It can be seen that some of the H plots gave more yield than some of the better fertilized I plots. Indeed, some of the G plots, which were left without additional potash, yielded more than some of the plots in the other two series that received

Table I.

Hamakua Experiment 41 AK, 1938 Crop

G series 0 lb. K_2O per acre		H series 175 lb. K_2O per acre		I series 350 lb. K_2O per acre	
Plot No.	Yield, tons	Plot No.	Yield, tons	Plot No.	Yield, tons
55	53.1	64	65.3	73	56.6
74	57.2	56	62.6	65	63.1
56	53.9	75	50.1	57	51.0
58	43.3	67	36.3	76	48.9
77	42.8	59	44.0	68	45.5
69	48.5	78	43.1	60	56.7
61	38.3	70	48.5	79	46.9
80	44.9	62	56.8	71	49.5
78	42.9	81	47.9	63	43.5
Average yields:	47.2 ± 2.21		50.5 ± 2.75		52.3 ± 1.85

potash. In other words, there is indiscriminate overlapping of yields in all the series.

Still, when the three columns are separately added up and the averages taken, it will be seen that on the whole the yield has been increased. The H plots, which were treated with 175 pounds of potash, have on the whole yielded more than the no-potash plots; and the I plots, with 350 pounds of potash, yielded more than the H plots. An investment in 350 pounds of potash per acre thus apparently assures an increased yield of 5.1 tons of sugar cane per acre. In former days, if a farmer could see a profit from this increased yield, he would proceed to act on the information supplied by the experiment.

However, since the extension of the concepts of experimental statistics into quantitative work in biology, this simple outlook has been overclouded. With or without the assent of the biologists concerned, the mathematical statisticians have elected to regard unexpected or unexplained variations in the results of biological experiments as a sign of "error," which may be due to chance happenings that have occurred without the knowledge of the operator or beyond his control. Hence, say the statisticians, things may not be what they seem; in view of the varying yields from the G plots, for instance, some or all of these plots may have been affected by unseen, irregular or transient circumstances, which would not be the same if the experiment were repeated in the same place in the same way, so that on repetition of the experiment a different total and hence a different average yield may be obtained. Agronomic action based on the apparent results of the experiment would therefore expose the farmer on the one hand to risk of a financial loss on a yield less than he expects, and on the other hand he stands a chance of obtaining a larger profit if the averages turn out more favorably than expected.

Having thus premised the situation, the mathematical statisticians come forward with mathematical methods by which the farmer may estimate the degree of risk. These methods are based on the mathematical theory of probability, for which an experimental basis has been provided by intensive study of such chance happenings as the tossing of coins to see which faces will turn up, the throw of dice to see which numbers will come uppermost, the cut and deal of a pack of cards, etc.

The original and simplest variant of these statistical methods is to calculate the "mean error" of a series of separate observations. Applied to the yield figures of the nine G plots in Table 1, the statistical mean error of this series is found to be 2.21 tons per acre, or, as commonly expressed, the average yield of these plots is at the rate of 47.2 ± 2.21 tons. In the statistical conception of probability in these matters, this means that a repetition of the experiment will most likely produce an average

[1] Borden, R. J. Studies in experimental technique. *Hawaiian Planters' Record*, vol. 43, p. 7 (1939).

yield somewhat between 47.2 — 2.21 or 44.99 tons, and 47.2 + 2.21 or 49.21 tons. The range of probable variation in this series is therefore 4.42 tons. Similar calculations show that the statistical range of error in the H series is 5.5 tons and in the I series 3.70 tons.

In recent times the science of experimental statistics has progressed far beyond this simple treatment of mean error. We now have the method of analysis of variance originated by R. A. Fisher which has found wide use in various modifications. When analysis of variance is applied to this Hamakua experiment, the range of statistical error for the whole area is reduced to 1.41 tons to the acre (see original paper). We will not here undertake a further comparison of old and new statistical methods for the use of agricultural workers because, in the agrobiologic view, they are all defiled with the same pitch, in that they ignore elementary facts of plant growth and yield. It is to be distinctly understood, however, that this last remark is directed only to the use of statistical methods in the matter which forms the subject of this paper—the criteria of field experiments in the use of plant nutrients. It is admitted that in other departments of agronomic experimentation the analysis of variance has a certain use. The reason for this discrimination will appear in the sequel.

Having premised the foregoing, consideration will be directed to the circumstances which may or do cause variations in the results of field experiments with plant nutrients. These circumstances may be grouped under three main heads.

1. Operative Errors

The operator may not fulfill the obligation to maintain strict uniformity in his control of the experiment. The ground may have been irregularly prepared; the fertilizer may not be well distributed; there may be failure to establish and maintain a uniform stand; various plots may be differentially affected by disease or insects, due to inadequate protection of the crop; mistakes may be made in harvesting, weighing and recording the individual crops.

2. Biological Variations

Individual plants growing side by side in the same soil may and often do differ in inherent vegetative vigor; for instance, sugar beets grown in the same row may weigh from half a pound or less to three pounds or more and contain from 14 to 25 per cent of dry substance. Obviously, if by chance one plot receives a larger proportion of the weaker individuals and a companion plot a relatively larger proportion of the stronger ones, this will establish a disparity between the yields of these plots independently of differential treatment with the nutrient.

3. Soil Variation

While an effort is always made to locate the experiment on a uniform field, it is a fact that an absolutely uniform area of soil large enough for a field experiment hardly exists anywhere. This variation affects all soil characters: granulation, texture, porosity, permeability, colloid content, organic matter, effective water retention, reaction (pH), and content of the common and the secondary plant nutrients. These nutrients themselves are subject to relatively large variations: there may be relatively little nitrogen, relatively much potash, relatively little phosphate and vice versa, in an endless variety of combinations that vary from one plot to the next, and each such combination exercises a characteristic influence on the yield of the crop.

All these sources of "error" appear to furnish rich meat for the statistical pot, and the devisers of statistical methods for the use of agriculturists have made much of it. They have produced dozens of manuals on the subject, and all these manuals contain a section dedicated to the statistical evaluation of field tests with plant nutrients. However, it is legitimate to observe that, while the author of such a manual may be eminent as a mathematician and as a statistician, he may not be also an accomplished agrobiologist. Let us again go over the three main sources of variation in such experiments to see whether they are really susceptible of statistical evaluation in any useful sense.

In reconsidering the operative errors, we will recall the assumption that was made at the begining, namely, that the operator will be competent, conscientious and well supplied with assistants and materials. The work of an untrained, ill equipped or careless experimenter will deserve small consideration, statistically or otherwise. On the other hand, no good experimenter will leave anything to chance that can be made secure by prudence. He will at all times be in full control of the situation so far as concerns maintenance of uniform conditions from beginning to end; if he is conscious of failure in this respect, he will abandon the experiment. From experience and observation it is my conviction that no field experi-

(Continued on page 26)

Pasture Notes

Compiled by R. H. LUSH
Pasture Specialist, The National Fertilizer Association

Arkansas

Fertilize Fall Grain. "For fall grains, including oats, rye, barley, and wheat, we recommend either superphosphate and muriate of potash prior to planting, or a complete fertilizer if the soil is particularly deficient in nitrogen. In both cases we recommend top-dressing in the spring," says Charles F. Simmons, extension agronomist.

California

Plants and Animals Must Feed Well. Dr. Samuel Lepkovsky, associate professor of animal husbandry, told the Defense Nutrition Institute recently "Plant foods vary greatly depending upon the soils on which they are grown, the fertilizers employed, and climatic conditions. Animal foods, including milk, will vary depending on how the animal is fed. Well-nourished animals will yield foodstuffs of higher nutritive value than poorly nourished animals."

Connecticut

Twenty Years with Pastures. In summarizing the grazing work in Connecticut, Prof. B. A. Brown says that since 1932 superphosphate alone continued to increase yields about 70 per cent; superphosphate and limestone, approximately 120 per cent; and complete fertilizer plus additional nitrogen, nearly 200 per cent. In that work, acre value of increased pasture over the cost of fertilizer was $18.70 for the complete fertilizer as compared to $7.50 for superphosphate alone, while limestone plus superphosphate gave a net increase in value of $13.40 per acre. A study of fertilizer penetration indicates that no particular effort should be made to work fertilizers into pasture soil.

Georgia

Needs More Fertilizer. E. D. Alexander, extension agronomist, in giving recommendations for quickly establishing sod on a training field in south Georgia. recommended the use of Bermuda grass and 1,000 lb. of complete fertilizer an acre plus additional amounts of nitrogen during the season. This has given excellent results in quickly establishing a turf on newly graded fields. "As fertilizer is so important in establishing pasture, it is logical to use even more for quick results and a more dense turf as in airplane training fields," reasons Agronomist Alexander.

Indiana

Productivity Increases with Fertilizer. The results of 10 years of pasture improvement demonstrations in southern Indiana show an increase in yield of 50 per cent the first season of treatment, and an increase of 106 per cent the second year following the initial application. The increased yields were much higher on a percentage basis than from the use of fertilizer on any other field crop. There are 75 pasture improvement demonstrations being carried on at present in the state.

These results show that most old permanent pasture are in need of phosphorus unless previously manured or fertilized. Recommendations are to apply superphosphate at the rate of 300 lb. to 600 lb. an acre, preferably in the fall or early spring. In some cases, potash may also be needed, and an application of 0-14-6 is suggested. Liming is usually a prerequisite in improvement as shown by soil and plant tissue tests.

Louisiana

Begin with the Soil. R. A. Wasson, extension agronomist, in urging better pasture, says that soils lacking phosphate or lime do not produce enough pasturage to assure proper growth or production of healthy cattle from which sufficient meat and dairy products of high nutritional value can be obtained. "It's a case of nutrition beginning with the soil," he says.

Missouri

Wheat-Lespedeza Best Combination. Four years results by the college of agriculture show that a wheat-lespedeza pasture combination gave 144 cattle days of grazing, and 302 pounds of beef per acre per season as compared to 93 days pasture and 183 pounds of beef per acre for bluegrass. These results show that permanent pasture should be considered as only one part of a yearly grazing system, states J. R. Paulling, field crops specialist.

New Jersey

Produce More Feeds. In this year of serious feed shortage, it may be possible to fer-

tilize old timothy sods of permanent pastures rather late in the season. It is a good time to put more land in sod with timothy seeded in winter grain, and clover broadcast next spring. Pastures are a valuable part of the farm, and treating them well pays good dividends, says H. R. Cox, extension agronomist.

New York

Produce More Roughage. Irrespective of milk prices, nutrients can be supplied at a lower cost in hay, pasture, and silage than in grain. All possible hay should be cut and properly cured. Seed rye not later than September 1st for fall and early spring grazing. Where silage corn has not been adequately manured, consider side-dressing with about 100 pounds of a nitrogen-carrier per acre. Manage the permanent pasture so it will give the maximum amount of fall grazing, suggests E. L. Worthen, extension agronomist.

Ohio

Good Meadows from Summer Seedings. An advantage of summer seeding is that applications of mineral fertilizer can be made directly for the forage seeding. Use 300 to 400 pounds of superphosphate or 0-14-6 per acre. A mulch of four or five tons of manure or one ton of straw after seeding conserves moisture, reduces soil temperature, and protects against winter heaving. *Ohio Agri. Exp. Sta. Bul. 588.*

South Carolina

Plant Winter Grains. When oats, wheat, rye, and barley are grown in rotation with cotton or other crops where liberal amounts of a complete fertilizer are used, a top-dressing of nitrogen may be the most profitable practice. On soil which does not receive a complete fertilizer for the other crops in the rotation, it is often necessary to use a complete fertilizer in addition to top-dressing to get satisfactory yields. *South Carolina Sta. Circ. No. 60.*

Tennessee

Poor Grass—Poor Animals. W. C. Lassetter, commenting on the Tennessee experimental work in which calves getting hay rich in phosphorus gain more rapidly than those getting the same amount of hay low in phosphorus says, "Pity the poor cow grazing on pasture on poor land. Even the little she gets is of less value." —*The Progressive Farmer, July, 1941.*

Vermont

Plant Food Removed. "A 20-cow dairy which, during the pasture season averages 4,000 pounds of milk per cow, so be it the milk was sold from the farm as such, would in 30 years drain the farm of 5 tons of nitrogen, 2 tons each of phosphoric acid and potash, and 3 tons of lime. These removals are a prime cause of the failure of clover stands, especially those of white clover which thrives only on somewhat moist and relatively rich soils . . . He who could fertilize his permanent pastures, and is in doubt as to their specific needs, may well . . . use a complete fertilizer, and in case acidity is a factor, apply lime." *Vermont Sta. Bul. No. 464.*

Virginia

Fertilized Pastures Resist Dry Weather. In a paragraph on "Fertilizers are Worth the Money," a statement is made that during recent dry weather fertilized pastures afforded good grazing and non-fertilized pastures were lacking on the same kinds of land.—*Department of Agriculture and Emigration, Bul. No. 393, 1941.*

Wisconsin

Pasture Should be Fertile. "It requires only a moment's observation to note that land that has been in pasture for 40, 50, or more years is not producing enough grass, unless it has been fertilized and some attention given to cultivation, to pay the taxes. Pasture land should be fertile land. It should be used in the rotation where possible. Grass land should be fertilized when it is seeded. If this is not possible, fertilizer may be applied after seeding. Such pasture is profitable.—*Hoard's Dairyman, June 25, 1941.*

ANNUAL REPORT SHOWS SALES GAIN FOR A. A. C.

American Agricultural Chemical Company for the fiscal year ended June 30th showed a net operating profit before provision for taxes of $1,556,873, compared with $1,043,608 in the preceding fiscal year. After deducting $435,000 provision for Federal income taxes, based on present proposed rates, the net profit amounted to $1,121,873, equal to $1.79 a share on the 627,969 shares. Net profit for the previous year was $908,608, after $135,000 deduction for taxes, or $1.45 a share on 627,981 shares then outstanding. Net sales were $22,330,492, a gain of $3,299,850 compared with the preceding year.

Beyond and Behind the Boom*

By MERLE THORPE
Editor, Nation's Business

(Continued from the August 16, 1942, issue)

Pretty nearly every day someone rises to ask with varying degrees of asperity and discouragement: "Why is business always against everything? Why don't businessmen stand for something constructive? This is a fast-moving world, and old ideas have to be scrapped. But to every suggestion of legislative change, businessmen rear up in opposition."

That's a fair question, and ought to be answered if there is to be an understanding of the pressing problems of production. We need new light on the problem which will become the country's terrifying No. 1 problem after the war—the rehabilitation and the reconstruction. Let's take a look.

It seems this opposition springs from the fact that when legislators propose changes, the businessman has stated his case very badly. He usually closes the argument by saying, "It won't work. It will be bad for business. It will be bad for both customer and worker." Now here are some examples:

Several years ago when the New Deal advocated a program of scarcity, businessmen opposed it, but, in so doing, used none of the persuasiveness they use in the selling of their own products. The businessmen said, in effect, that "it won't work," that "it will be bad for business," failing to add that what is bad for business is bad for the country—bad for both customer and for worker. So as a result, he gained the reputation of being "agin" a plan which was presented to the people as a panacea for all their depression ills.

What the businessman should have said was: "We businessmen believe in production. We believe that only by producing more things can we have more things for more people. The more we make, the more we do, the higher standard of living we shall all enjoy. Therefore, since this theory of scarcity violates our belief in what is good for all of us, we ask close study of a new and untried national plan."

Here is another example: Business opposes the perverse and oppressive legislative restriction of its activities. But its reputation is that it is against legislation promoted in the public interest. Business could have made its opposition constructive by saying that it stands for the old American tried-and-true plan of stimulation of, and reward for, individual initiative; that the strength of the country is the strength of the individual; that anything which impairs the full operation of the individual's ability, capacity, resourcefulness and energy is inimical to the best interest of the country, and, therefore, that restrictions which hamper and tie the hands of those engaged in business enterprise should be carefully considered before official approval makes them the law of the land.

This sort of opposition is really constructive because business is saying that the country should consider carefully whether unusual and unnecessary restrictions will prevent the increased production and distribution of things, for here again the business man goes back to his major premise that the standard of living is based on the number of things produced and available to the people in exchange for their labor.

Here is a third example: The businessman has been "agin" the spend-lend program, but has not been persuasive in his approach to his opposition. He would have been constructive if he had said that continual deficits mean greater tax burdens and that this is not only a burden upon him, the individual business man who produces and distributes things, but also that it is a greater burden upon the consumer whom he serves; that, in effect, he is only a tax collector because he must charge more for the goods he makes and has less left with which to increase the wages of his employees.

Another example: The business man is well known to have been skeptical of the plans for a "more abundant life," but his doubt relates solely to political dispensations. For 150 years the business man has not only been "for" the more abundant life, but has gone out and matched faith with works. It is not the objective but the political procedure he questions. He doubts the efficacy of New Deal methods. He does not believe that subsidy-for-scarcity plans will ultimately result in other than a less abundant life. His prescription for the abundant life is, again, production, ways and means of getting and using more things for many

* An address at the Annual Dinner of the National Fertilizer Association, White Sulphur Springs, W. Va., June 10, 1941.

people, not necessities alone, but those things we call the extras, the conveniences and the luxuries.

That is why the business man is for leaving as much as possible of what the laborer receives for his work in the laborer's hands—a surplus to be spent by the man who earns it, rather than a surplus to be taken for taxes and spent by Government activities which reduce our ability to produce and have the material things each one of us can use to good purpose. He understands to the full the forceful words of President Roosevelt when he said: "Taxes are paid in the sweat of every man who labors." He knows that taxes come from the work-bench and never from the park-bench.

It is true that the business man has a reputation of being against Government expansion and innovation, but here again he has allowed himself to be put in a false light. His position is quite simple: He is for spending the people's money for all the people; he knows the people's interest is rooted in making income equal outgo.

As to labor: Business as a whole is against the Wagner Act as written and administered, not because it opposes collective bargaining in itself, but rather because it is for, and has been for, collective bargaining without the compulsion and duress on employees applied through labor racketeers or through Government partisanship.

Government Competition

When business says that it is against Government competition, what it is really saying is that it wants greater opportunities for the individual citizen.

The wealth of the United States has decreased from $428,000,000,000 to $362,000,000,000. Income has dropped from $672 to $490 per capita, and according to William Green, who has taken Government figures, the standard of living dropped 8 per cent in ten years.

You as fertilizer manufacturers know from stark experience what Government competition portends. You have seen distribution of fertilizer by TVA and AAA rise from practically nothing in 1935 to 9.68 per cent of all fertilizer plant food distributed in 1940. You have heard, within the past few weeks, of the construction of facilities for a 50 per cent increase by TVA in its already large-scale production of superphosphate. You doubtless are viewing with well-founded apprehension the almost certain advent of commercial production of fertilizer nitrogen by the same Governmental agency as soon as the present emergency requirements for munitions nitrogen have passed.

Business supported the Walter-Logan bill, but it gave ground for an impression that it was bucking the new legislative liberality which allows bureaus to rule by administrative decree. Business should have made its case clearer by stating that it is for a Government of law, law written out, whereby each citizen may know what the law is. If there is an alleged violation, the citizen can then look to a court for a fair trial. As a people we have hated Government by decree, and there is little difference between Government by decree of a single ruler and Government by decree through bureaus, commissions, authorities and boards, responsible to one man. For that reason the business man was for the Walter-Logan Bill, which, in effect, was to assure him recourse to the courts.

The Profit System

Business has been held up to shame because it believes in the profit system. In fact business men have been put in the absurd position of justifying the profit motive. It ought to be clear, but apparently it is not, that every exertion of spirit, mind or body looks to reward. Recreation is of profit to the physical being. Church attendance is to profit one's spiritual being. The study of art, exposure to music is to profit the cultural being. No need to labor the point. It takes realistic incentive to stir mankind to new growths, new ideas, new services, new conquests of the unknown.

The profit system has a decent motive and can be properly credited with the progress of mankind. That fact explains why the businessman is "against" government activities which head society inevitably toward State socialism. In his practical experience, his knowledge of human nature leads him to regard as most unreal the slogan: "Production for use only and not for profit." He is even cynical enough to point out that the League for Industrial Democracy, which has such a theme for its activity, works overtime to get more members, to increase its revenues and, not least to pay higher salaries to its officers. He sees in these purposes incentives readily identifiable with the profit motive.

The businessman is concerned to assure opportunity for every individual. Therefore, he resists policies which foster class distinctions and class conflicts.

Business points out that the law prohibits an employer from bringing in outside strike-breakers; sees no reason why the same law

(Continued on page 24)

THE AMERICAN FERTILIZER
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PIONEER JOURNAL OF THE FERTILIZER INDUSTRY

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Publication Date of "Minerals Yearbook" Advanced

In response to unprecedented demand for comprehensive information on metals, nonmetals, fuels, and mineral products, from the mineral industries and from Government defense agencies, the U. S. Bureau of Mines has scheduled publication of its Minerals Yearbook more than three months in advance of last year's date, it has been announced by Dr. R. R. Sayers, Director of the Bureau.

The current edition of Minerals Yearbook, containing the most inclusive collection of facts and statistics on mineral industries ever assembled, will be placed on sale by the Superintendent of Documents early in September.

This expanded volume of the Bureau's annual series, reviewing the progress and developments in the mineral industries during 1940, said Director Sayers, includes hitherto unavailable information relating to strategic and critical minerals which has never before been published.

As an official reference work and as an authoritative statistical record of the United States' and world production, distribution, trade and consumption of minerals, the Minerals Yearbook will provide public and private agencies concerned in national defense activities with a factual basis for policies, programs and action. The new 1,500-page volume gives special consideration to minerals vital to the defense program. For instance, it provides statistics of magnesium production in the last three years and of magnesium consumption in each industry, the results of a survey of bauxite reserves, a discussion of stocks of and requirements for nickel, and estimates of mercury reserves and probable output of mercury at various price levels as determined through a canvass of the more important producers.

The Minerals Yearbook is recognized throughout the world as the outstanding book in its field, and the current volume features improved charts and new subjects. One new chapter, for example, entitled "Effect of the International Situation on United States Trade in Minerals," discusses the stimulation of import trade by the national defense program, the control of exports essential to the procurement program, alternate sources of strategic minerals, and Latin America as a potential source of supply. Another new chapter presents a summary of the principal developments during the year and also a detailed historical record of the establishment and organization of

the various Government defense agencies. Each of the minerals discussed in earlier volumes is covered in the new edition, and in many instances the coverage has been expanded.

Prepared by nationally and internationally known specialists in the field of mineral economics and technology, under the direction of E. W. Pehrson, Chief of the Economics and Statistics Branch, Bureau of Mines, the 1941 Minerals Yearbook includes data on more than 100 minerals; it contains 1,459 pages, 72 chapters, 97 figures, and a complete index. Copies may be obtained from the Superintendent of Documents, Washington, D. C. The price is $2.00.

F. C. BAKER ELECTED PRESIDENT OF AMERICAN POTASH

The American Potash & Chemical Corporation last week named F. Cecil Baker president and elected three other officers vice-presidents. Mr. Baker succeeds H. S. Emlaw, resigned, who will continue as a director and a member of the executive committee.

Mr. Baker has been with the company since 1924. In recent years he has been vice-president of the potash concern and manager of the American interests of the Consolidated Gold Fields of South Africa, Ltd.

Named vice-presidents were R. W. Mumford, consulting chemical Engineer, who has been with the company since 1920; W. J. Murphy, sales manager, who has been with American Potash and Consolidated Gold Fields for thirty years, and Peter Colefax, who is now secretary and treasurer. All three will hold their former posts.

PRIORITIES FOR FERTILIZER MACHINERY REPAIRS

Individual applications for preference rating on materials for maintenance and repair of existing equipment for fertilizer manufacture are usually being promptly granted at present. For many weeks The National Fertilizer Association has been endeavoring to have maintenance and repair materials for the fertilizer industry placed under a blanket order so that individual applications will not be necessary. A very few industries have been so favored to date. It is hoped that the industry will be specifically included in the next general maintenance order.

In the meantime, if a manufacturer needs a preference rating in order to obtain repair parts or materials, an application should be made by filling out in detail the blank form PD-1, "Application for Preference Rating," and sending it with a letter of transmittal to Mr. Joseph L. Overlock, Assistant Deputy Director of Priorities, Office of Production Management, Washington. A copy of the letter of transmittal should be sent to Dr. Philip Groggins, Office of Agricultural Defense Relations, U. S. Department of Agriculture, who is following up priorities for agriculture. The letter of transmittal should state in general terms the nature of the repairs and what final product comes from the equipment being repaired. Blank PD-1 forms may be obtained from the Priorities Division of the Office of Production Management.

JULY SULPHATE OF AMMONIA PRODUCTION

Figures from the U. S. Bureau of Mines show that the production of by-product sulphate of ammonia during July continued at current high levels. During the month, 62,585 tons were produced, which was an increase of about 2 per cent over June figures of 61,392 tons, and about 3 per cent over July, 1940, figures of 60,806 tons. For the first seven months of the year, production totaled 430,940 tons in 1941 and 402,007 tons in 1940. Stocks on hand at the manufacturing plants amounted to 39,455 tons on July 31st, an increase of 20 per cent over the 32,641 tons on hand June 30th.

Production of by-product ammonia liquor also continued steady, July figures showing 2,738 tons (NH_3 content) as compared with 2,703 tons in June and 2,370 tons in July, 1940. For the January-July period, the output was 18,452 tons in 1941 and 15,924 tons in 1940. On July 31st, stocks on hand totaled 789 tons, a drop of 6 per cent from stocks of 842 tons on hand June 30th.

MILLIMAN NOW ON OPACS STAFF

On August 18th, T. E. Milliman, head of the fertilizer department of Cooperative G. L. F. Soil Building Service, joined the staff of OPACS (Office of Price Administration and Civilian Supply). He will work on problems connected with the fertilizer industry. His company has granted him a six-months leave of absence to assume this work.

The American Chemical Society

Abstracts of Papers to be presented at the Meeting of the Division of Fertilizer Chemistry at Atlantic City, N. J., September 8 to 12, 1941

Boron and Manganese in Tomato Production

Jackson B. Hester, Campbell Soup Co., Riverton, N. J.

Using a special technique of growing sunflowers in 500 grams of soil for an investigation of soils low in available boron, some 839 individual fields were tested. The samples largely came from New Jersey and Pennsylvania. Eighteen per cent of these soils were low enough in available boron to produce symptoms of deficiency on the plant. There appeared to be no definite relation between soil texture and the occurrence of the deficiency, although a greater percentage of sandy soils were deficient. More acid soils produced the deficiency symptoms than less acid soils. Certain counties in New Jersey showed a far higher occurrence of deficiency than other counties.

Manganese has been found to be associated with the vitamin C content of tomatoes—that is, soils with a low soluble manganese content were found to produce tomatoes with a low vitamin C content. There also appears to be a relation of sugars to vitamin C in the fruit. Four factors were found to influence the readily soluble manganese in certain soils, (1) quantity of total manganese, (2) pH value, (3) organic matter content, and (4) salt concentration.

Significance of Trace Elements in Plant Nutrition

John W. Shive

The role of boron, iron manganese, etc., in plant nutrition, as shown by experiments at the New Jersey Agricultural Experiment Station, is pointed out. Symptoms of deficiency of various trace elements are illustrated.

The Behavior of Borax in Mixed Fertilizers

Frank O. Lundstrom and J. Richard Adams, Fertilizer Research Division, Bureau of Plant Industry, Washington, D. C.

Soluble salts of the minor elements are toxic to plants at concentrations much below that at which those of the primary elements cause burning in plants. The uniform distribution of the minor elements in mixed fertilizers is therefore essential if all parts of the fertilizer are to contain an adequate supply of each minor element without localized concentrations that would be toxic to the plant. In a study of the uniformity with which small quantities of a minor element can be incorporated in a mixed fertilizer, four samples of three mixed fertilizers containing 2, 10, and 40 pounds of borax per ton were collected at intervals as they were discharged from the mixing drum of a commercial fertilizer plant. The total borax in the four samples of each set agreed quite well with the theoretical value and with that in a fifth sample representing the fertilizers as placed on the market. A satisfactory incorporation of a small amount of borax in a fertilizer mixture should therefore be possible under commercial conditions.

Boron forms a volatile compound with fluorine but no loss of boron occurred when a superphosphate mixture containing 0.5 per cent of borax was stored for 44 hours at 100° C. A decrease in water-soluble but not of acid-soluble boron was indicated under these conditions.

Borax reacts with such components of a mixed fertilizer as ammonium sulfate and monocalcium phosphate. These reactions in-

(Continued on page 22)

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FERTILIZER MATERIALS MARKET

NEW YORK

Little Change in Market. British Purchase of Sulphate of Ammonia Reported with Similar Imports from Canada. Chemical Fertilizers Still in Strong Demand.

Exclusive Correspondence to "The American Fertilizer."

NEW YORK, August 27, 1941.

There has been very little change in the general fertilizer situation in the last week although buying of commodities in general has slowed up to some extent.

The demand for sulphate of ammonia, potash and nitrate of soda still continues, with no change in the schedules of prices previously announced by producers and importers.

Within the last week the British Purchasing Commission has come into the market for 10,000 tons of sulphate of ammonia for fairly prompt shipment and probably at this time have managed to book more than half the required quantity, which has depleted spot stocks to some extent and many of the regular domestic buyers are awaiting deliveries against shipping orders previously placed.

The British Purchasing Commission have arranged for their Export License and it is understood that an equal quantity of sulphate of ammonia will be imported from Canada to replace the above tonnage. However, Canadian material will probably be shipped to Hawaii principally, so that this replacement will not help the situation on the East Coast.

Tankage

Not much business is passing in this material. Fertilizer grades are being quoted at $3.75 ($4.56 per unit N) and 10 cents, with feeding tankage offered at $4.50 ($5.47 per unit N) and 10 cents. South American tankage is priced at $4.25 ($5.16½ per unit N) and 10 cents.

Superphosphate

Producers are maintaining the schedule previously announced. Demand continues good with no excessive stocks apparent.

Nitrogenous Material

Quoted at $2.75-$3.00 ($3.34½ to $3.64½ per unit N), f.o.b. eastern producing points. Supplies are none too plentiful.

Fish Scrap

There has been no change from previous advices regarding menhaden scrap. Sales have been reported at $4.25 (5.16½ per unit N) and 10 cents, f.o.b. Chesapeake Bay producing points. Fish meal is quoted at $65.00 per ton.

Dried Blood

The market continues quiet with no change in prices. Local production is quoted at $3.50 ($4.25½ per unit N), with imported material bringing $3.25 ($3.95 per unit N), when transportation is available.

ATLANTA

Demand for Sulphate of Ammonia Exceeds Supply. Spanish Potash Quoted. Cottonseed Meal Higher.

Exclusive Correspondence to "The American Fertilizer."

ATLANTA, August 25, 1941.

While there has been no change in the price on sulphate of ammonia, it is becoming increasingly difficult to get commitments from the producers on current orders. Steel production is at a peak but, notwithstanding, the demand for sulphate has been in excess of the supply. What the future situation may develop, remains to be seen.

Quite a number of the manufacturers are turning to nitrate of soda (which, of course, is higher per unit), especially since liquids are likewise in short supply.

Potash, especially of the higher grades, is likewise scarce although some Spanish material has recently been quoted for nearby arrival, this being the 40 per cent grade.

Cottonseed meal is considerably firmer and continues so since the Government crop estimate came out the early part of August. Prices have advanced around $5.00 to $6.00 per ton during the summer months.

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Nashville, Tenn.
New Orleans, La.
New York, N. Y.
Norfolk, Va.
Presque Isle, Me.
San Juan, P. R.
Sandusky, Ohio
Wilmington, N. C.

The market generally is as follows:

Imported Tankage.—$4.25 ($5.16½ per unit N) and 10 cents, c.i.f.

South American Blood.—$3.60 ($4.37½ per unit N), c.i.f.

Domestic Nitrogenous Tankage.—$2.50 ($3.04 per unit N), western producing points.

Menhaden Machine Dried Scrap.—$60.00 per ton, f.o.b. South Atlantic producing points.

Acidulated Fish. — Nothing currently available.

Sulphate of Ammonia.—Unchanged.

Nitrate of Soda.—Chilean, $30.00 bulk through October 31st, basis f.o.b. the ports.

Cottonseed Meal.—Prime 8 per cent, $35.75, Memphis; southeastern mills, $36.00.

BALTIMORE

Market on Fertilizer Materials Quiet. Feeding Materials at High Levels. Ceiling on Bag Prices Eases Burlap Market.

Exclusive Correspondence to "The American Fertilizer."

BALTIMORE, August 26, 1941.

As is usual at this time of the year, activity in the market on fertilizer materials is very quiet. The market on organic ammoniates for feeding continues high.

Ammoniates.—Ground animal tankage for feeding purposes is in short supply and figures about $5.25 per unit of nitrogen and 10 cents per unit of B.P.L., f.o.b. basis Baltimore, in comparison with ground dried blood, which only figures about $5.20 per unit of nitrogen.

Nitrogenous Material.—This article is nominally quoted at $3.50 per unit of nitrogen, f.o.b. Baltimore, but with the demand practically nil.

Sulphate of Ammonia.—There is nothing new in the situation surrounding this material which is still in short supply, and while the nominal market is $29.00 per ton at the ports, there is none obtainable at this figure, although there are buyers willing to pay a premium. Even at higher figures there is no re-sale material available.

Nitrate of Soda.—The demand continues light, and the market is firm on the basis of previously announced schedule through October 31st, at $33.00 per ton in 100-lb. bags, $32.40 in 200-lb. bags and $30.00 in bulk, f.o.b. port warehouse.

Fish Scrap.—There has been little activity during the past few weeks in this material, and the market remains unchanged at $5.40 per unit of nitrogen, and 10 cents per unit of B.P.L.. f.o.b. fish factory, in bulk, for shipment as produced.

Superphosphate.—The market on this is likewise unchanged, and firm at $9.50 per ton of 2,000 lb., basis 16 per cent, for run-of-pile. and $10.00 for flat 16 per cent grade, both in bulk, f.o.b. producers' works, Baltimore.

Bone Meal.—The price on both raw and steamed bone meal has now gotten to a point where it is not attracting much interest and 3 and 50 per cent grade is nominally quoted at $37.00 to $38.00 per ton, while 4½ and 47 per cent is priced at $38.00 per ton, f.o.b Baltimore.

Potash.—There has been no activity noted in this for sometime past, although shipments against contracts booked sometime ago are starting to arrive.

Bags.—The burlap market has eased up considerably since announcement of ceiling prices, and the present market is about $194.00 per thousand, for new 10 oz. bags, basis 40 cut 54 in., delivered Baltimore for the fall season.

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CHARLESTON

Fertilizer Materials Continue Scarce. Higher Prices Quoted on Some Organics.

Exclusive Correspondence to "The American Fertilizer."

CHARLESTON, August 25, 1941.

A shipment of Chilean nitrate has just been discharged at Jacksonville. Other minerals continue very scarce.

Nitrogenous.—This is getting more scarce and quotations more difficult to obtain. Quoted around $2.85 ($3.46½ per unit N), delivered southeastern ports.

Blood.—Around $3.30 ($4.01 per unit of N), bagged, c.i.f. ports where freight can be obtained. Around $3.60 ($4.37½ per unit N), bulk, Chicago.

Fish Meal.—Fish scrap is quoted at $4.25 per unit of ammonia ($5.16½ per unit of N) and 10 cents per unit B.P.L., f.o.b. Baltimore. Dried menhaden meal is quoted at $65.00 per ton, f.o.b. Baltimore.

Cottonseed Meal.—8 per cent grade at $34.50, f.o.b. Memphis; $34.00, f.o.b. Atlanta.

Superphosphate.—A growing scarcity for this season on superphosphate is developing.

CHICAGO

Little Business Being Done in Fertilizer Organics. Uneasiness Noted in Feed Market.

Exclusive Correspondence to "The American Fertilizer."

CHICAGO, August 25, 1941.

The organic market was quiet since our last report. Sellers are slow in putting out offerings; and meanwhile buyers seemingly have adopted a waiting policy. The same conditions rule in the bone meal market, and no important changes are likely to occur in the near future.

A slight easiness is noticable in the feed market. While list prices of the finished product are unchanged, mixers hesitate reaching for material at sellers' price views.

Nominal prices are as follows: high grade ground fertilizer tankage, $3.50 to $3.75 ($4.25½ to $4.56 per unit N) and 10 cents; standard grades crushed feeding tankage, $4.75 to $4.85 ($5.77½ to $5.89½ per cent N) and 10 cents; blood, $3.60 to $3.75 ($4.37½ to $4.56 per unit N); dry rendered tankage, 92 cents to $1.00 per unit of protein, Chicago basis.

TENNESSEE PHOSPHATE

Favorable Conditions for Agriculture and Rock Production Continue. Phosphate Demand Increases.

Exclusive Correspondence to "The American Fertilizer."

COLUMBIA, TENN., August 25, 1941.

Beautiful summer weather with very little excessive heat and fairly frequent rains, the prospects of splendid crops of corn, tobacco and hay, livestock in good condition, all mines in full operation and activity in the shipping of phosphate, combine to make the outlook most favorable to this section which so largely depends on agriculture and the phosphate industry.

Consumers for all lines of phosphate are actively calling for shipments and inquiries of brokers, exporters and dealers, as well as consumers, are such in evidence for phosphoric acid, red phosphorus and all the phosphate chemicals for defense purposes and for use in the many lines consuming them. While these manufactured articles are produced in several plants here, the sales offices of all the companies manufacturing them are located in Atlanta, Richmond, New York, Chicago and St. Louis, so that little can be ascertained here as to actual market conditions.

As usual, activity and hence scarcity and in-

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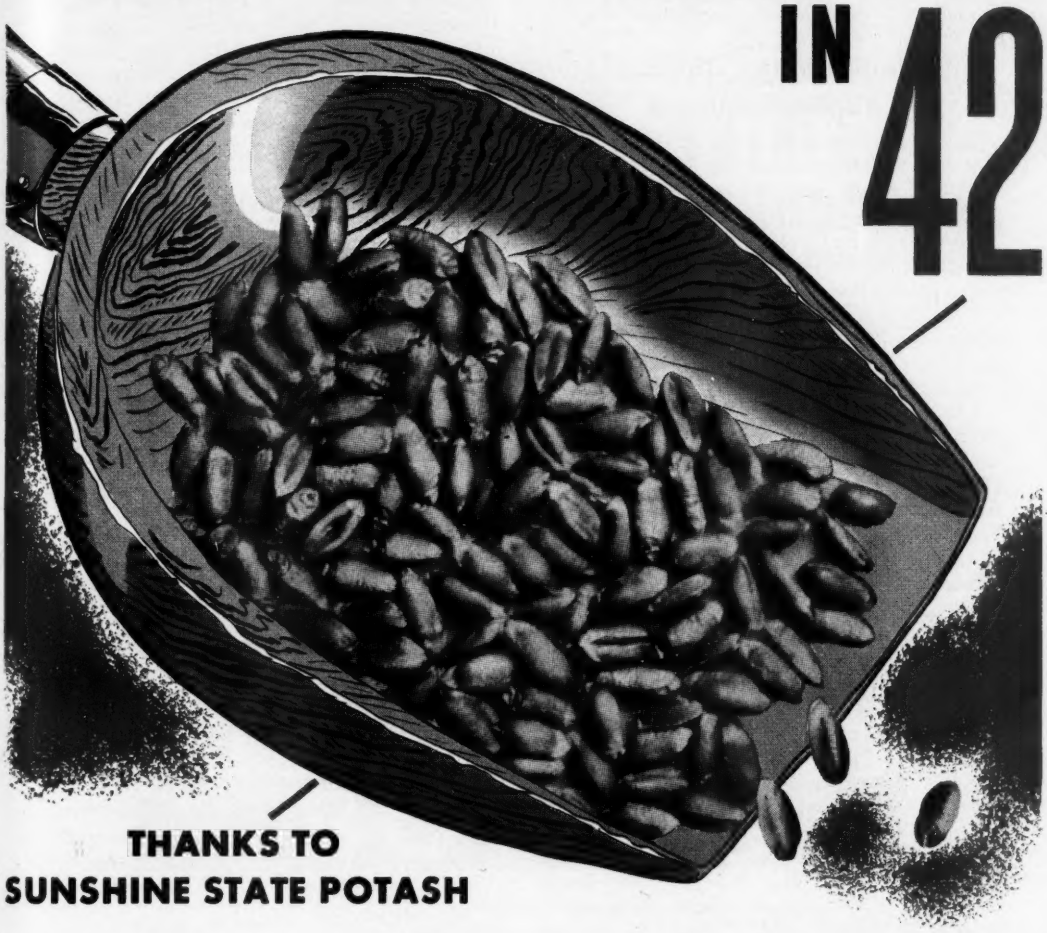

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creasing prices in these manufactured products gives rise to increased demand for phosphate rock, both as raw material and in efforts to substitute the natural unmanufactured product for finished products in many lines.

Conditioning Russian Superphosphates

Soviet standards for superphosphate require that this material contain not less than 18.7% assimilable P_2O_5 and not more than 5.5% free P_2O_5. The superphosphates leaving certain Soviet plants had a too high content of free P_2O_5 and too low content of assimilable P_2O_5 and it was necessary to bring these contents to standards by extra measures. This was accomplished by addition of bone meal to the superphosphate while it was being loaded on the freight cars for shipping to the consumers.

Laboratory experiments showed that the addition of 4% of bone meal to superphosphate which had been stored 10 days and contained 17.5-17.9% assimilable P_2O_5 and up to 8.5% free P_2O_5, produced a decrease in free P_2O_5 to 5.0-5.4% and an increase in assimilable P_2O_5 to 18.2% within 2 hours. The superphosphate and bone meal must be very thoroughly mixed.

The Molotov superphosphate plant had a large quantity of superphosphate which could not be shipped to the consumer because it did not comply with the standards required. Most of it had been stored 19 days on the average and it contained 17.9% assimilable P_2O_5 and 6.4-8% free P_2O_5, with a moisture content of 13-14%. The bone meal used contained 30% P_2O_5 and 40% CaO. It was calculated that 1.77 parts by weight of CaO, therefore 4.4% bone meal, was necessary to neutralize 3% free P_2O_5. This adds 1.3 parts by weight P_2O_5 to each 100 parts by weight of the superphosphate. Since bone meal decomposes readily, the P_2O_5 contained therein goes over to the assimilable form.

It must also be taken into account that the superphosphate decomposes somewhat on cooling and handling during loading and therefore increases the content of assimilable P_2O_5. The decrease of moisture in the superphosphate after addition of bone meal also increases the assimilable P_2O_5 in the superphosphate.

All these calculations were found to be correct in actual practice. Samples were taken from some 30 places in the carload and analysis showed that the assimilable P_2O_5 contained varied from 18.5 to 18.8%, and the free P_2O_5 content did not exceed 3.3%. This superphosphate also had excellent physical properties—it was dry, crumbly, and it did not become sticky on compression, or form lumps during transportation.

The superphosphate at the Voskresenski Chemical Combinat contained 16.7-16.8% assimilable P_2O_5 and 7% free P_2O_5. A 4.3% addition of bone meal lowered the free P_2O_5 to 4.7% within 2 hours, to 3.2% within a day, and to 2.9% within 2 days. The assimilable P_2O_5 rose to 17.5% within a day.

Only superphosphate which has been manufactured under fairly strictly controlled conditions and subjected to cooling and mixing can be brought to standard contents of assimilable and free P_2O_5 by addition of bone meal during loading. Less carefully prepared superphosphate (with no cooling or mixing) cannot be standardized by addition of bone meal during loading. The addition of bone meal will improve the chemical composition but standard contents can be attained only on delivery to the place where it is to be used. Supplementary decomposition occurs in this superphosphate during transportation. *Abstract of article from the Journal of Chemical Industry (Russia). Reprinted from "Chemical Industries."*

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70 PINE STREET, NEW YORK CITY
Pioneer Producers of Muriate of Potash in America
See Page 4

THE AMERICAN CHEMICAL SOCIETY

(Continued from page 14)

crease the caking tendency of the mixture when the borax is present in any considerable amount by setting free water of crystallization and by the crystal growth of the reaction products.

Boron compounds of reduced solubility may be prepared by forming melts of borax with varying proportions of silica. This treatment not only decreases the toxicity of the borax to plants but also its influence on the caking of mixtures in which it is stored.

The Preparation of Synthetic Composts for Mushroom Culture

B. B. Stoller, L. F. Lambert Mushroom Spawn and Products Co., Coatesville, Pa.

A synthetic compost for mushroom culture is prepared by adding source materials that will produce 12 to 20 pounds N, 3 to 6 pounds P_2O_5, and 9 to 16 pounds K_2O to a ton of fibrous materials having a moisture content of 65 to 75% after allowing for the presence of these constituents in the fibrous material. One of the chief causes for the failure of previous attempts to prepare satisfactory composts or "artificial manures" has been the omission of potash. The effect of variations in the N-P-K ratio, pH, quantity of compost per square foot, subdivision and character of fibrous material sources of nitrogen, and duration of composting on the yield of mushrooms is reported. By combining tannin or lignin with the nitrogenous material the lengthy microbial decomposition may be avoided.

Factors Influencing Formation and Availability of Insoluble Nitrogen Compounds from Urea-Ammonia Liquor-37

F. W. Parker and F. G. Keenen, E. I. duPont de Nemours & Co., Wilmington, Del.

Urea-ammonia liquor-37 is a fertilizer ammoniating solution characterized by the fact that one-fifth of its nitrogen becomes water-insoluble in ammoniation and subsequent storage operations. The insoluble nitrogen compounds formed are urea-formaldehyde reaction products. Under proper conditions of manufacture and storage, their plant food availability approximates that of dried blood. Nitrification experiments show that high availability is obtained by reacting formaldehyde with more than 100 per cent molal excess of urea when hydrogen ion concentrations are between pH 3.5 4.5. Low availability is shown by compounds formed when molal ratio of urea to formaldehyde is less than 2. Resins, wherein this ratio is less than 1, nitrify very poorly.

Cooling Ammoniated Fertilizers

Edward F. Harford, E. I. duPont de Nemours & Company, Wilmington, Del.

Considerable progress has been made during the past season by the fertilizer industry in installing rotary coolers for ammoniated fertilizer mixtures. More than 100,000 tons of mixed fertilizer have been cooled to date with these units which have an annual capacity of 400,000 tons. Operations of factory units have been in accord with the design data previously reported. A brief review is given of temperature effects upon reactions leading to reversion of available P_2O_5 and the result of cooling upon stability of ammoniated mixtures.

The Determination of K_2O in Commercial Fertilizers Using 95% and 80% Alcohol and Acid Alcohol

C. W. Hughes and O. W. Ford, Department of Agricultural Chemistry, Purdue University Agricultural Experiment Station, Lafayette, Ind.

Laboratory work has indicated that in the case of fertilizers with a K_2O content ranging from 1 to 6 per cent there is obtained about 0.1 per cent more K_2O when 95 per cent alcohol and acid alcohol is used than is obtained when 80 per cent alcohol and acid alcohol is used.

With an increase in K_2O content, there is a greater difference shown by the use of the two strengths of alcohol and acid alcohol. With muriate of potash, there is as much as 0.3 per cent more K_2O found when 95 per cent alcohol and acid alcohol is used than when 80 per cent alcohol and acid alcohol is used as in the present A. O. A. C. method for K_2O in fertilizers.

Availability of Phosphorus in Ammoniated Phosphates—Laboratory vs. Crop. A Review.

R. M. Jones and L. V. Rohner

The present Association of Official Agricultural Chemists' laboratory method for evaluating available phosphoric acid in ammo-

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niated superphosphate and fertilizer mixtures containing it, gives results lower than those obtained from crop tests. The official method, therefore, places a burden of extra cost on the fertilizer consumer by (1) limiting unduly the amount of the lowest cost nitrogen (solutions containing free ammonia) which can be used in fertilizer mixtures and (2) making necessary the installation of expensive rehandling and cooling equipment to prevent formation of citrate-insoluble P_2O_5.

Crop tests reported by Ross, Jacob, and Beeson indicate that P_2O_5 found to be insoluble or unavailable by the chemical method is available to plants on soils having a pH of 6 or under. The same authors point out that soils in this classification constitute 90% of the domestic tillable land on which 75% of the total fertilizer is consumed.

A change in the chemical method to bring results more in agreement with crop data is therefore indicated.

BEYOND AND BEHIND THE BOOM

(Continued from page 11)

should not be applied to labor unions which bring in outside strikers and picketers; still cleaves wholeheartedly to the belief that mutuality of interest should be reflected in all laws and their interpretations.

As to the present situation: Business knows that in a normal year 80 billion man-hours of labor are required to furnish the people with the necessities and conveniences of life to which they have been accustomed. The defense program is calling upon twenty billion of those man hours to do an additional job. Because of its inherent belief in the production of goods and services as bringing the greatest comfort and well-being and morale to the people, business is spending anxious hours in trying to figure out how this 25 per cent reduction of the things the people have been accustomed to and need, can be met.

It believes that this deficiency in the standard of living can be cushioned only by easement of restraints, restrictions and regulations now hindering management, giving it a freer hand at bringing men and materials together, and by official discouragement of all work stoppages adverse to the public interest.

It believes in the principle and practice of competition but it does not believe that wholesale and indiscriminate investigations and indictments under the Sherman Antitrust Act, with their attendant enormous costs and deadly dissipation of energy, make any contribution to meeting the problems of the present emergency. It believes rather that every dollar of resources and every ounce of energy it possesses should be utilized for the supreme necessity of the moment—production, greater and greater production, for defense and civilian needs to the end that the American way of life shall be preserved. In a very real sense it is a disservice to the nation to charge business with responsibilities which are impossible to meet by reason of conditions issuing from public policy.

Behind the scenes at Washington today a titanic struggle is under way. The battle lines are drawn. On the one side are those who would change our form of society. On the other side are businessmen who wish to organize the country's industrial machine for the greatest war aid, but who, after the war effort is over, wish to see a return to individual ownership of industry. They fear, and rightly, that many moves in the war effort will result in a more or less permanent collectivist or socialistic framework of American society.

They fear deeply the possible destruction of the American way of life. They feel it is a real threat because some of our leaders, by their own admission, had lost faith in America before the present emergency arose, and today in the nation's distress are working for a new order of their own, an America of nationalized industry and agriculture, a regimented way of life.

Furthermore, business recognizes and hopes the Government will recognize that our No. 2 problem today will some day become the nation's terrifying Number 1 problem, the demobilization of war effort, the reconstruction of peaceful ways of life. While Washington boasts of its national planning ability, too

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little thought is given to planning for after the war.

There business stands, and not business with a big B. Its ideals spring from three million managers of enterprises, and indeed from forty million workers associated with them. Business is patriotic. It believes in providing a national defense that is impregnable, in promoting the general welfare, in establishing justice. It has been shocked into the position of opposition to the public weal, because it has argued over a road map, because it thinks Route 1776, with all its hill-climbing, is better than Route D of C No. 1. Such difference of opinion is no proof of lack of patriotism. Businessmen see, as their forefathers did, the great danger of centralized political power, that with it will come the absence of economic freedom. They sense what philosophers have discovered, that economic freedom is blood brother to the five other great freedoms of the individual—religion, press, assembly, petition and speech.

If business holds fast to these ideals and keeps the faith, much of the distress which will naturally follow the war-time boom will be eliminated in the hard days of reconstruction.

A CRITIQUE OF FIELD EXPERIMENTS WITH PLANT NUTRIENTS

(Continued from page 7)

menter worth his salt commits operative errors that affect the results by as much as one per cent; variations arising from this source are therefore relatively infinitesimal.

In the matter of biological variation, the competent operator also takes full control of the situation. It is true that individual plants may show marked deviations from the varietal average, but the mean error of the average can be made as small as desired by taking a sufficiently large number of individuals; all the manuals explicity set forth methods for testing the adequacy of samples. For example,[2] by using valid statistical principles verified by practical experience, it has been found that to reduce biological variation in the sugar beet (a very variable organism) it is necessary to have at least 800 plants per plot if the accuracy desired is to be within 2 per cent; with a smaller number the error will be larger and with a greater number it will be less. It is a mark of competence in the agronomic experimenter that he knows the coefficient of biological variability of his test plant and governs himself accordingly. He is thus enabled and should be expected to make this source of error also infinitesimal.

Cultural operations and biological variation being thus removed from consideration as sources of variation in any practical sense, the large observed discrepancies can only be due to the third putative source of error—soil variability. But to ascribe variable yields from varying soils to the workings of chance, or as in any way subject to statistical probability in any useful sense, is to discount the fundamental natures of both soils and plants.

The soil is the locus of the factors of plant growth that are under consideration in this paper. A living plant and any one or any combination of its growth factors are the two members of a mass-action system which is governed by natural laws that are as inflexible and as universal in the plant world as the law of gravity is in the physical world. Alter the mass or intensity of the soil member of this system and you alter the vital response of the plant and hence the mass of dry vegetable substance it produces. Leave the soil member unaltered but substitute a plant species of greater or lesser vigor and you increase or diminish the mass of vegetable substance obtained. What the yield will be in any given case will therefore depend on the reaction-strengths of the two members. If the concentration or intensity of the soil member is large and the vigor of the plant is great, the yield will be great; and conversely. If the reaction-strength of one member is high and that of the other member is low, the actual product will correspond to the agrobiologic mean of the reaction-strengths of the two members. Thus the same result may be obtained by operating in two opposite senses: a large concentration of soil potash (for instance) and a variety of low vigor may produce a result no different from the combination of a low concentration of potash and a variety of great vigor. The point is that every closed system comprising a definite combination of growth factors and a definite stand of plants is characterized by a definite and characteristic yield of vegetable substance.

(Continued in the next issue)

[2] Thoens, H. How many sugar beets are required for reliable estimation of yield and sugar content? *Centralblatt f. Zucker-Industrie*, vol. 48, No. No. 4, pp. 65-67 (1940); abstracted in *Facts About Sugar*, vol. 35, No. 7, p. 37 (1940).

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the number of pounds of raw material for a desired per cent. of plant food in a ton of mixed goods—or find what per cent. of a certain plant food in a ton of fertilizer produced by a specific quantity of raw materials.

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BUYERS' GUIDE

A CLASSIFIED INDEX TO ALL THE ADVERTISERS IN "THE AMERICAN FERTILIZER"

This list contains representative concerns in the Commercial Fertilizer Industry, Including fertilizer manufacturers, machinery and equipment manufacturers, dealers in and manufacturers of commercial fertilizer materials and supplies, brokers, chemists, etc.
For Alphabetical List of Advertisers, see page 33.

ACID BRICK
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

ACID EGGS
Chemical Construction Corp., New York City.

ACIDULATING UNITS
Chemical Construction Corp., New York City.
Sackett & Sons Co., The A. J., Baltimore, Md.

AMMO-PHOS
American Cyanamid Co., New York City.

AMMONIA—Anhydrous
Barrett Company, The, New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.
Hydrocarbon Products Co., New York City.

AMMONIA LIQUOR
Barrett Company, The, New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.
Hydrocarbon Products Co., New York City.

AMMONIA OXIDATION UNITS
Chemical Construction Corp., New York City.

AMMONIATING EQUIPMENT
Sackett & Sons Co., The A. J., Baltimore, Md.

AMMONIUM NITRATE SOLUTIONS
Barrett Company, The, New York City

AUTOMATIC ELEVATOR TAKEUPS
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

BABBITT
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BAGS—Cotton
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BAGS—Paper
Bagpak, Inc., New York City.
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS (Waterproof)—Manufacturers
Bemis Bro. Bag Co., St. Louis, Mo.

BAGS—Dealers and Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

BAGGING MACHINES—For Filling Sacks
Atlanta Utility Works, East Point, Ga.
Bagpak, Inc., New York City.
Sackett & Sons Co., The A. J., Baltimore, Md.

BAG PILERS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.

BEARINGS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
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BELT LACING
Sackett & Sons Co., The A. J., Baltimore, Md.

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Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

BELTING—Leather, Rubber, Canvas
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.

BOILERS—Steam
Atlanta Utility Works, East Point, Ga.

BONE BLACK
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Armour Fertilizer Works, Atlanta, Ga.
Huber & Company, New York City.

BONE PRODUCTS
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

BORAX AND BORIC ACID
American Potash and Chem. Corp., New York City.
Pacific Coast Borax Co., New York City.

BROKERS
Ashcraft-Wilkinson Co., Atlanta, Ga.
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Huber & Company, New York City.
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Keim, Samuel L., Philadelphia, Pa.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

BUCKETS—Elevator
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BUCKETS—For Hoists, Cranes, etc., Clam Shell, Orange Peel, Drag line, Special; Electrically Operated and Multi Power
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.

BURNERS—Sulphur
Chemical Construction Corp., New York City.

BURNERS—Oil
Monarch Mfg. Works, Inc., Philadelphia, Pa.
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CABLEWAYS
Hayward Company, The, New York City.

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American Agricultural Chemical Co., New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.

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Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CARTS—Fertilizer, Standard and Roller Bearing
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

CASTINGS—Acid Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.

CASTINGS—Iron and Steel
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
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CEMENT—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

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Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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Fairlie, Andrew M., Atlanta, Ga.

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Baker & Bro., H. J., New York City.
Barrett Company, The, New York City.
Bradley & Baker, New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.

CHEMICALS—Continued
Huber & Company, New York City.
Phosphate Mining Co., The, New York City.
Wellmann, William E., Baltimore, Md.

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Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
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Link-Belt Company, Philadelphia, Chicago.
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Fairlie, Andrew M., Atlanta, Ga.

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Dickerson Co., The, Philadelphia, Pa.
Phosphate Mining Co., The, New York City.

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Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

CRANES AND DERRICKS
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.
Sackett & Sons Co., The A. J., Baltimore, Md.

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Bradley & Baker, New York City.
Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

DENS—Superphosphate
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For an Alphabetical List of all the Advertisers, see page 33

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Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

DRYERS—Direct Heat
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.

DRIVES—Electric
Link-Belt Company, Philadelphia, Chicago.

DUMP CARS
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
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Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ELEVATORS AND CONVEYORS—Portable
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

ENGINEERS—Chemical and Industrial
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Fairlie, Andrew M., Atlanta, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ENGINES—Steam
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Sackett & Sons Co., The A. J., Baltimore, Md.

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Link-Belt Company, Philadelphia, Chicago.
Link Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.

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American Cyanamid Co., New York City.
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Farmers Fertilizer Co., Columbus, Ohio
International Agricultural Corporation, Chicago, Ill.
Phosphate Mining Co., The, New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

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Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

FOUNDERS AND MACHINISTS
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GARBAGE TANKAGE
Wellmann, William E., Baltimore, Md.

GEARS—Machine Moulded and Cut
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GEARS—Silent
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

GELATINE AND GLUE
American Agricultural Chemical Co., New York City.

GUANO
Baker & Bro., H. J., New York City.

HOISTS—Electric, Floor and Cage Operated, Portable
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.

HOPPERS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

IMPORTERS, EXPORTERS
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

IRON SULPHATE
Tennessee Corporation, Atlanta, Ga.

INSECTICIDES
American Agricultural Chemical Co., New York City.

LACING—Belt
Sackett & Sons Co., The A. J., Baltimore, Md.

LIMESTONE
American Agricultural Chemical Co., New York City.
American Limestone Co., Knoxville, Tenn.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

LOADERS—Car and Wagon, for Fertilizers
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Acid Making
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Duriron Co., Inc., The, Dayton, Ohio.
Fairlie, Andrew M., Atlanta, Ga.
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Coal and Ash Handling
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Elevating and Conveying
Atlanta Utility Works, East Point, Ga.
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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MACHINERY—Power Transmission
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MACHINERY—Pumping
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Duriron Co., Inc., The, Dayton, Ohio.

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MAGNETS
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Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MANGANESE SULPHATE
McIver & Son, Alex. M., Charleston, S. C.
Tennessee Corporation, Atlanta, Ga.

MIXERS
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Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

NITRATE OF SODA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Company, The, New York City.
Bradley & Baker, New York City.
Chilean Nitrate Sales Corp., New York City.
Huber & Company, New York City.
International Agricultural Corporation, Chicago, Ill.
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Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

NITRATE OVENS AND APPARATUS
Chemical Construction Corp., New York City.

NITROGEN SOLUTIONS
Barrett Company, The, New York City

NITROGENOUS ORGANIC MATERIAL
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
DuPont de Nemours & Co., Wilmington, Del.
Huber & Company, New York City.
International Agricultural Corporation, Chicago, Ill.
McIver & Son, Alex. M., Charleston, S. C.
Smith-Rowland Co., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

NOZZLES—Spray
Monarch Mfg. Works, Philadelphia, Pa.

PACKING—For Acid Towers
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

PANS AND POTS
Stedman's Foundry and Mach. Works, Aurora, Ind.

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Chemical Construction Corp., New York City.

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Huber & Company, New York City.
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Ruhm, H. D., Mount Pleasant, Tenn.
Schmaltz, Jos. H., Chicago, Ill.
Southern Phosphate Corp., Baltimore, Md.
Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

PIPE—Acid Resisting
Duriron Co., Inc., The, Dayton, Ohio.

PIPES—Chemical Stoneware
Chemical Construction Corp., New York City.

PIPES—Wooden
Stedman's Foundry and Mach. Works, Aurora, Ind.

PLANT CONSTRUCTION—Fertilizer and Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

POTASH SALTS—Dealers and Brokers
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Agricultural Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

POTASH SALTS—Manufacturers and Importers
American Potash and Chem. Corp., New York City.
Potash Co. of America, Baltimore, Md.
United States Potash Co., New York City.

PULLEYS AND HANGERS
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

PUMPS—Acid-Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

PYRITES—Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., New York City.
Jett, Joseph C., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

QUARTZ
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

RINGS—Sulphuric Acid Tower
Chemical Construction Corp., New York City.

ROUGH AMMONIATES
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Schmaltz, Jos. H., Chicago, Ill.
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SEPARATORS—Air
Sackett & Sons Co., The A. J., Baltimore, Md.

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Link-Belt Company, Philadelphia, Chicago.
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SEPARATORS—Magnetic
Sackett & Sons Co., The A. J., Baltimore, Md.
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SHAFTING
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

SHOVELS—Power
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.
Sackett & Sons Co., The A. J., Baltimore, Md.

SPRAYS—Acid Chambers
Monarch Mfg. Works, Inc., Philadelphia, Pa.

SPROCKET WHEELS (See Chains and Sprockets)

STACKS
Sackett & Sons Co., The A. J., Baltimore, Md.

SULPHATE OF AMMONIA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
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Texas Gulf Sulphur Co., New York City.

SULPHURIC ACID
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Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.

SULPHURIC ACID—Continued
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Wellmann, William E., Baltimore, Md.

SUPERPHOSPHATE—Concentrated
Armour Fertilizer Works, Atlanta, Ga.
International Agricultural Corporation, Chicago, Ill.
Phosphate Mining Co., The, New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

SYPHONS—For Acid
Monarch Mfg. Works, Inc., Philadelphia, Pa.

TALLOW AND GREASE
American Agricultural Chemical Co., New York City.

TANKAGE
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
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Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
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McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
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Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

TANKAGE—Garbage
Huber & Company, New York City.

TANKS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons, Co., The A. J., Baltimore, Md.

TILE—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

TOWERS—Acid and Absorption
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

UNLOADERS—Car and Boat
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

UREA
DuPont de Nemours & Co., E. I., Wilmington, Del.

UREA-AMMONIA LIQUOR
DuPont de Nemours & Co., E. I., Wilmington, Del.

VALVES—Acid-Resisting
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

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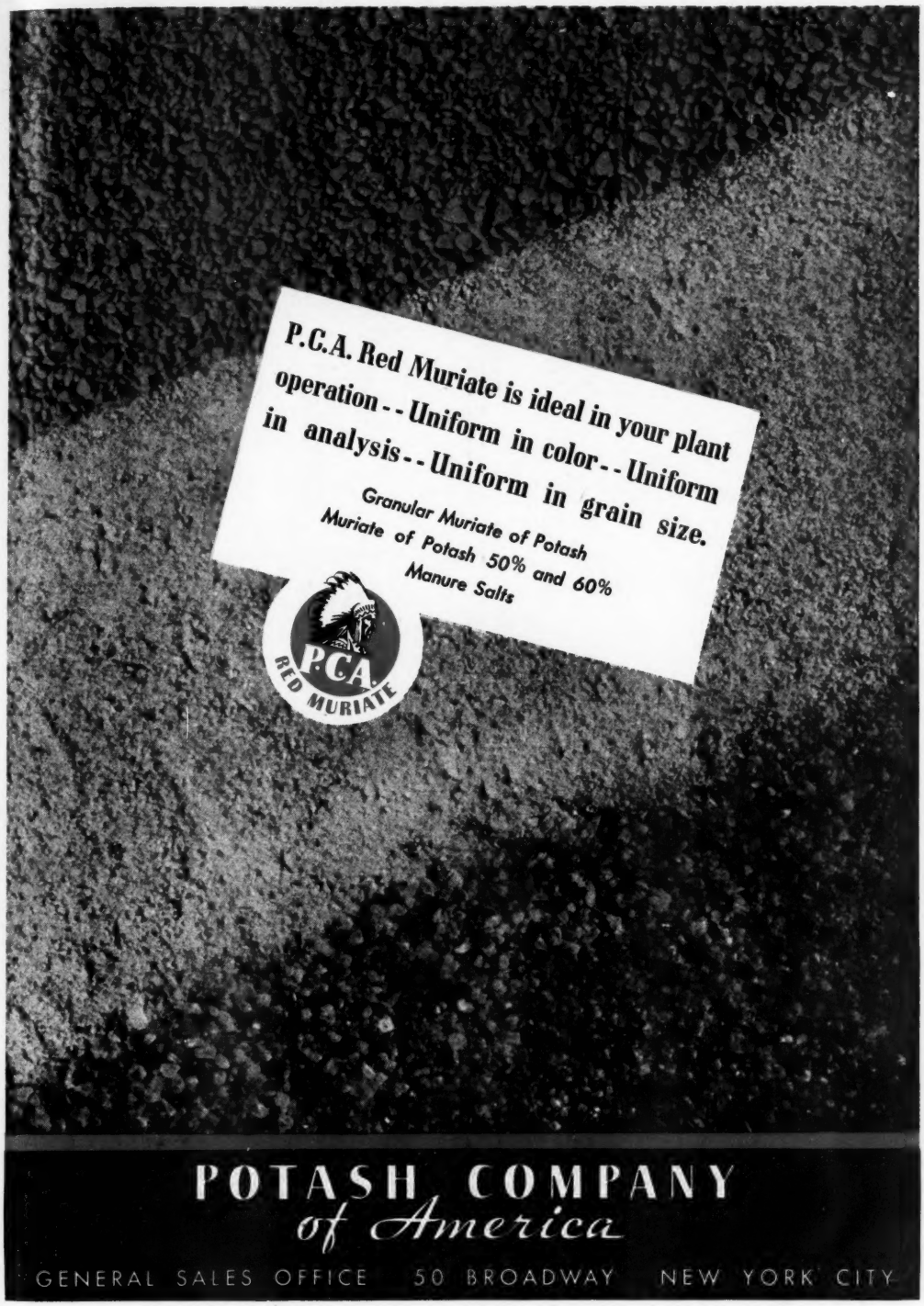
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